CONSTRUCTION QUALITY ASSURANCE PLAN

FORD MOTOR COMPANY
ALLEN PARK CLAY MINE
CELL II

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COPY 2

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CELL II

This document has been prepared by NTH for Ford Motor Company to comply with an EPA request to set forth quality assurance requirements for construction of the Allen Park Clay Mine Hazardous Waste Disposal Cell II. The document conforms to the requirements presented in the Liner Engineering Report dated June, 1988 prepared by NTH, the engineering design drawings prepared by MCI, and the closure plan prepared by Ford.

I. AREAS OF RESPONSIBILITIES

This section contains a description of the general division of responsibility between various parties to be involved in construction at the Allen Park Clay Mine Cell II. Detailed responsibilities are provided in appropriate sections of this document.

A. FML Installer (FMLI)

The FMLI will install high density polyethylene (HDPE) flexible membrane liners at the locations shown on the engineering drawings. The FMLI will conduct their own construction quality control/assurance program with respect to liner installation, pre-construction material inspection, in-place seam integrity testing and in-field pre-weld strength testing; and will provide full documentation of liner installation and seam and raw material testing. The FMLI will also supply Ford Motor Company (Ford) with the required material test results to be obtained from the liner manufacturer.

B. Net & Fabric Installer (NFI)

The NFI will install all synthetic drainage nets and fabrics at the locations shown on the engineering drawings, with the exception of fabrics used around collector pipes and over the bottom collection layer in the primary leachate collection system as shown on the engineering drawings. These will be installed by EWC personnel under the direction of the Construction Quality Assurance (CQA) Officer. The NFI will also supply material testing results generated by the manufacturer of these materials and inspect these materials for damage prior to placement. The NFI will

conduct their own quality control/assurance program and will document the placement of the synthetic drainage nets and fabrics according to generally accepted standards.

C. Independent Testing Engineer (ITE)

An independent testing organization will be retained by Ford for the project. Personnel from this organization will be under the supervision of the ITE. The ITE or his representative will conduct laboratory testing for soils used in construction and will perform field moisture content and density testing of soils during earthwork operations. The ITE or his representative will also observe the installation of the HDPE, primary and secondary liners.

The ITE or his representative will perform QA/QC activities specified in appropriate sections of the CQA Plan and will prepare daily field reports of his observations as well as reports of laboratory tests.

D. Ford Motor Company (Ford)

Ford will serve as the head agency, to which all subcontractors as wells as the CQA Officer are directly responsible. Ford will appoint the CQA Officer for the

project and will employ all other organizations who will be doing work on this project.

E. Construction Quality Assurance (CQA) Officer

The CQA Officer will be responsible for supervision of all the contractors and construction quality assurance personnel on site. The CQA Officer will be responsible for construction supervision, construction inspection and completing the work as shown on the design drawings and as specified herein.

Specific duties of the CQA Officer include: overall supervision of personnel and contractors involved in construction, coordination between the various constructors, inspection of construction materials, acceptance/rejection of completed work, confirmation of as-built construction conditions in accordance with engineering plans and specifications, documentation of construction conditions, preparation of as-built construction documents, and certification that the Cell II liner and associated components are constructed as designed.

F. Earthwork Contractor (EWC)

The EWC will provide the construction equipment and personnel needed to perform all construction activities specified in this document. The EWC will use earthmoving equipment in construction operations as specified in relevant sections of this document.

G. Land Surveying Contractor (LSC)

The LSC will provide equipment and personnel needed to perform all surveying activities specified in this document.

II. QUALIFICATIONS

Minimum qualification requirements for various organizations involved with the construction Allen Park Clay Mine Cell II are provided below.

A. FML Installer

The FMLI must be trained and qualified to install HDPE synthetic liners. Qualification requirements of the FMLI are included Section XIII:G of this document.

B. Net & Fabric Installer

The NFI must be trained and qualified to install the drainage nets and filter fabrics specified in engineering design drawings. To demonstrate necessary training and qualifications, the NFI must provide Ford with information relating to at least three previous projects. Information will include: name of project; location; date; names of installer's crew; type of net/fabric; thickness of net/fabric; surface area; type of seaming; duration of installation; and available information on the performance of the project. The NFI crew supervisor must have experience in seaming at least 100,000 square meters of drainage net and filter fabrics.

C. Independent Testing Engineer

An independent testing organization capable of providing soil laboratory and field testing and construction observation will be retained by Ford. Personnel from the organization will be under the supervision of the ITE, who shall be a graduate of an engineering program and who is licensed as a Professional Engineer (PE) in the State of Michigan.

D. Quality Control/Assurance Officer

The CQA Officer shall be a graduate civil engineer, and will have a Professional Engineering license in the State of Michigan. The CQA Officer shall also have experience in hazardous waste land disposal facility construction similar to Allen Park Clay Mine.

E. Earthwork Contractor

The EWC shall be experienced in the construction of landfill liner system and EW construction projects.

F. Land Surveying Contractor

The LSC will be proficient in surveying techniques.

III. LINES OF AUTHORITY

Ford is the facility operator, prime contractor and has chief responsibility for completion of construction and for construction quality control and quality assurance. The CQA Officer, appointed by and responsible to Ford, shall have final authority with respect to all phases of construction associated with this project. Each contracting and inspection company shall retain responsibility for the supervision of their own employees

and the implementation of their own quality control/assurance programs. Supervisors assigned by each contracting or inspection company shall be under the direction of the CQA Officer. Acceptance or rejection of work, and implementation of the associated corrective actions shall be the responsibility of the CQA Officer.

IV. MEETINGS

A. Preconstruction Meetings

Prior to the start of work by any contractor, a preconstruction meeting shall be held by the CQA Officer. In this meeting, all involved parties will review applicable parts of the plans and specifications, as well as this CQA plan. In particular, the parties will review areas of responsibility, lines of authority and procedures for dealing with problems or rejected work. The inspection frequency, document distribution and criteria for acceptance or rejection of work will also be discussed. The CQA Officer shall document each preconstruction meeting and distribute minutes of the meeting to other parties, as necessary.

B. Daily Work Meetings

Each work day, the CQA Officer or his representative shall conduct a meeting with all constructors, inspection firms and CQA personnel to review the previous day's work and to discuss the current day's scheduled work. Any coordination or workmanship problems as well as potential problems along with possible solutions will be discussed at that time. The CQA Officer or his representative shall document the meetings and distribute minutes to other parties, as necessary.

C. Meetings To Resolve Problems

These meetings will be held on the site as necessary when the immediate nature of a construction of a construction problem precludes discussion at the next scheduled daily work meeting. At such a meeting, the problem will be defined and discussed by all concerned supervisors. Possible solutions will be discussed and a solution will be selected. Implementation procedure of the chosen solution will also be discussed and agreed upon. The CQA Officer shall document the meeting and distribute minutes, as necessary.

V. SUBBASE, STABILIZATION AND PERIMETER BERM CONSTRUCTION

The base of Cell II has been overexcavated to an approximate elevation of 560 feet mean sea level (msl). Prior to construction, compacted clay fill will be placed on the existing cell base to reach design grades and a stabilization berm will be built along the base of the cell as shown on the drawings. In addition, a perimeter berm will be built around the rim of Cell II to provide an anchor trench for the liner and cover systems.

A. General Specifications

1. Prior to base preparation, any existing water within the Cell II excavation will be removed prior to the addition of subbase fill. Some combination of the following approaches would be suitable for placing the fill.

    a. In the first approach, small sections of the base would be sectioned off and drained; then, earth fill compacted, as specified below, would be placed to the planned grade of the secondary FML. Such staging would also require the removal of saturated sediment beneath the submerged area to an

elevation where suitable native clay material is encountered.

b. Alternately, the area may be loosely filled, displacing the existing water, re-excavation of the loose fill in small sections may proceed to allow for staged subgrade preparation.

Fill used in base preparation should have a Unified Soil Classification of CL and, after completion, a permeability coefficient not greater than 1×10^{-6} cm /sec. Furthermore, it shall be compacted to not less than 90% of maximum dry density as determined by ASTM D-1557.

2. Construction within the Cell II will be staged in such a manner that the stability of the excavation slopes and base will be improved with each stage of construction. This involves the following steps:

a. Construct stabilization berms at the toe of the slopes on the north, west and south (grid directions) sides of the cell (MCI Drawing 8),

b. Construct liner system for the interior subcell,

c. Prepare the exterior subcell as described in Section VII.

3. The existing Cell II excavation will be filled or graded to achieve design elevations as shown on cell engineering design plans. Berms will also be constructed according to these plans.

4. Fill used in base and berm preparation should have a Unified Soil Classification (USC) of CL. After compaction, the permeability coefficient shall not exceed 1×10^{-6} cm/sec.

5. Clay fill material will be placed in horizontal lifts that do not exceed 9 inches in loose thickness.

6. Fill material shall be compacted to 90% of the maximum dry density as determined by the modified proctor compaction test (ASTM D-1557) and moisture content shall be within a range of -2% to +5% of optimum at the time of placement. More restrictive limits may be applied, if needed, to achieve strength and permeability criteria for silty clay.

7. Moisture/density restrictions that apply to I-696 clay and native on-site clay intended for use in the subbase and berms are presented on Plate 1, Cell II Liner System Construction Requirements.

8. As shown on Plate 1 of this document, cell subbase fill placed within the interior of the U-shaped stabilization berms will have a minimum shear strength of 500 psf.

9. As shown on Plate 1 of this document, fill used in construction of the U-shaped stabilization berms and in the perimeter berm should have a minimum shear strength of 2500 psf.

10. During winter construction, all ice, snow and other frozen material will be removed before placing any fill. No fill will be placed on a frozen surface and no frozen fill will be used for construction.

11. Foreign objects will be removed from fill prior to placement.

B. Testing

1. The field density and moisture content of the compacted clay will be determined by the nuclear densimeter method (ASTM Standard D2922 and D3018) on a frequency of at least 1 test per 1000 cubic yards placed, with a minimum of 1 test per day of construction or 1 test per layer placed.

2. The moisture-density relationship of subbase fill and berm materials will be re-determined according to ASTM Standard D-1557 when the texture of the soil changes and for every 5000 cubic yards placed. The grain size distribution, Atterberg limits and soil classification will also be determined at this frequency.

3. A laboratory determination of the coefficient of permeability with water will be made on a soil sample obtained from every 10,000 cubic yards of material placed. Samples will be obtained by cutting blocks of soil or by taking Shelby tubes from the compacted fill. The Shelby tube samples shall not exceed 1/2 of the total number of sample obtained for permeability testing. Falling head permeability tests will be performed according to one of the test methods detailed in USEPA publication SW-925 (1984). A coefficient of permeability greater than 1×10^{-6} cm/sec will be immediately reported to the Construction Quality Assurance (CQA) Officer for corrective action.

4. Shear strengths will be determined at a frequency of one test per day for materials placed with moisture contents within the ranges shown on Plate 1. If moisture contents are outside the specified ranges, or if soil characteristics change noticeably, shear strength tests will be performed at a minimum of one test per 2000 yards of material placed. Shear strength will be determined by vane shear tests or by laboratory strength tests performed on Shelby tube samples obtained in the field. The frequency of shear strength testing may be increased at the discretion of the CQA Officer.

C. Responsibilities

1. The CQA Officer will direct all earthwork operations during construction of the subbase and stabilization berms.

2. The Land Surveying Contractor (LSC) will survey base and berm areas as directed by the CQA Officer.

3. The CQA Officer will coordinate surveying of base elevations following the placement of subbase fill

to assure that base elevations are consistent with design grades shown on engineering design plans. The CQA Officer will also coordinate surveying of the stabilization berms during construction to assure conformance with construction sequence requirements and the design plans. Surveying frequency shall be specified by the CQA Officer.

4. The CQA Officer will be responsible for overall construction quality assurance of the cell subbase, stabilization and perimeter berms, and will certify that the construction has been performed according to engineering design plans and this CQA document.

5. The Independent Testing Engineer (ITE) or his representative will provide field density and moisture testing of fill placed.

6. The ITE will promptly notify the CQA Officer if materials or construction methods are not in accordance with design drawings of this CQA plan.

7. The ITE's representative will sample and perform laboratory testing of soils at the frequency required by this CQA plan.

8. The ITE or his representative will provide documentation of the construction and CQA activities in the form of a daily field report. This report will be distributed to the CQA Officer and will contain the result of CQA testing and other relevant information.

VI. SIDESLOPE PREPARATION

A. Filled Slopes

As shown on engineering design plans, fill will be placed in some areas along the Cell II sideslopes in order to achieve design grades in these locations. This fill will have the following general specifications.

1. General Specifications

   a. Fill used in sideslope and side berm preparation shall have a USC of CL. After compaction, the permeability coefficient shall not exceed 1×10^{-6} cm/sec.

   b. Clay fill material will be placed in horizontal lifts that do not exceed 9 inches in loose thickness.

c. Fill material will be compacted to 90% of the maximum dry density as determined by a modified proctor compaction test (ASTM D-1557) and moisture content shall be within a range of -2% to +5% of optimum at the time of placement. More restrictive limits may be applied, if needed, to achieve shear strength and permeability criteria for the silty clay.

d. Moisture/density restrictions that apply to I-696 clay and native on-site clay intended for use in sideslope preparation are presented on Plate 1, Cell II Liner System Construction Requirements.

e. As shown on Plate 1 of this document, fill used in construction of sideslopes and side berms should have a minimum shear strength of 2500 psf. Sufficient sand will be removed along the perimeter berm so that a minimum of 10 feet of recompacted clay with a permeability coefficient of less than 1×10^{-7} cm/sec is placed in these areas.

f. During winter construction, all ice, snow and other frozen material will be removed before placing any fill. No fill will be placed on a frozen surface and no frozen fill will be used for construction.

g. Foreign objects will be removed from fill prior to placement.

2. Testing

a. The field density and moisture content of the compacted clay will be determined by the nuclear densimeter method (ASTM Standard D2922 and D3018) on a frequency of at least 1 test per 1000 cubic yards placed, with a minimum of 1 test per day of construction or 1 test per layer placed.

b. The moisture-density relationship of sideslope and side berm fill materials will be re-determined according to ASTM Standard D-1557 when the texture of the soil changes and for every 5000 cubic yards placed. The

grain size distribution, Atterberg limits and soil classification will also be determined at this frequency.

c. A laboratory determination of the coefficient of permeability with water will be made on a soil sample obtained from every 10,000 cubic yards of material placed. Samples will be obtained by cutting blocks of soil or by taking Shelby tubes from the compacted fill. The Shelby tube samples shall not exceed 1/2 of the total number of samples obtained for permeability testing. Falling head permeability tests will be performed according to one of the test methods detailed in USEPA publication SW-925 (1984). A coefficient of permeability greater than 1 x 10^{-6} cm/sec will be immediately reported to the CQA Officer.

d. Shear strengths will be determined at a frequency of one test per day for materials placed with moisture contents within the ranges shown on Plate 1. If moisture contents are outside the specified ranges, or if soil characteristics change noticeably,

shear strength tests will be performed at a minimum of one test per 2000 yards of material placed. Shear strength will be determined by vane shear tests or by laboratory strength tests performed on samples obtained in the field.

3. Responsibilities

a. The CQA Officer will direct all earthwork operations during filling on side slopes.

b. The LSC will survey sideslopes to assure that sideslope elevations are consistent with design grades.

c. The CQA Officer will be responsible for overall construction quality assurance of the sideslopes and will certify that the construction is performed according to specifications.

d. The ITE or his representative will provide field density, moisture and strength testing of fill placed and will promptly notify the CQA Officer of materials or construction

methods not in accordance with the engineering drawings and this CQA document.

B. Cut Slopes

As shown on engineering design drawings, some cutting of sideslopes will be performed in order to achieve design grades.

1. General Specifications

a. Cut slopes will be rolled with a smooth steel drum, pneumatic roller or other approved means so as to be free of irregularities, loose earth or abrupt changes in grade. Cut slopes will be graded to smooth and true line.

b. Protruding stones and other sharp objects will be removed from exposed surfaces on cut slopes. Generally, objects greater than 2 inches in diameter shall be removed. Objects will be removed by hand after the slope is cut.

c. Elevations will be surveyed at periodic intervals along the length of the slope to ensure that the slope meets engineering design grades.

2. Responsibilities

a. Cutting of the sideslopes will be performed by the Earth Work Contractor (EWC) under the supervision of the CQA Officer.

b. The CQA Officer will approve earthmoving equipment used to cut the slopes.

c. Elevations will be taken by the LSC at the request of the CQA Officer.

d. The EWC will remove large, sharp objects along the slopes.

e. The CQA Officer or his representative will inspect surfaces of the cut slopes to ensure that they are free of large, sharp objects as defined herein.

f. The CQA Officer will certify that cut slopes have been prepared in accordance with engineering design plans and this CQA document.

VII. PRESSURE RELIEF SYSTEM

The proposed pressure relief system will consist of a series of wick drains generally spaced at 50-foot intervals along the cell base and located all around along the toe of the slope. These drains lead to collector pipes which in turn allow the captured groundwater to flow to a sump for eventual disposal. The water pressure relief system will be constructed in accordance with cell engineering design plans.

A. Wick Drains

1. General Specifications

a. The wick drains will consist of 5-foot wide strips of geosynthetic drainage net placed beneath the 80-mil FML.

b. All drainage nets will be joined with fasteners at an interval of 2 lineal feet or less.

c. The minimum transmissivity of the wick drain material will be 6.4×10^{-7} m^2/s.

d. A sheet of non-woven needle-punched geotextile fabric will separate the drainage nets from the underlying subbase clay.

e. Minimum overlap of the geotextile filter fabric shall be 12 inches. No portion of the geotextile shall be left exposed for more than 48 hours before being covered by the drainage net and the FML.

f. Geotextile filter fabric will have an equivalent opening size greater than 0.149 mm and less than 0.211 mm.

2. Responsibilities

a. The NFI shall install drainage net and fabrics at the locations shown on the drawings.

b. The NFI shall inspect all drainage net and fabric rolls stored on-site to verify that

the proper materials have been received for the work. The NFI shall also inspect for any damage which may have been caused by mishandling during transportation, unloading or storage.

c. The NFI shall document the overlap of nets and fabrics and shall inspect and document the method of joining/seaming of adjacent sheets.

d. The NFI shall document the method of fastening.

e. Upon completion of the pressure relief system, the CQA Officer and the NFI together shall verify total coverage and adequate fastening and restraint.

f. The NFI shall submit written documentation to the CQA Officer that drainage net and fabric has been installed according to engineering design plans and that in-place materials meet generally accepted standards of placement.

g. The CQA Officer will certify that drainage nets and fabrics used in the pressure relief system have been installed according to cell engineering design plans.

B. Pipes

1. General Specifications

a. Four-inch diameter high density polyethylene (HDPE) pipes will be used in the pressure relief system. The pipes will have a standard dimension ratio (SDR) of 21. The pipe invert will be perforated along each 5-foot length where it intersects the drainage wick. Perforations will consist of 2 rows of 1/4-inch holes at 4-inch intervals. Holes will be placed 60° apart.

b. The pipes shall be sloped at a minimum 1% grade.

c. MDOT Series 34 open-graded aggregate (pea gravel) will envelope the HDPE pipes as shown on cell engineering design plans. Geotextile fabric shall be placed around the

pipes and gravel section as shown on the drawings to function as an interface filter between the clay subbase and the pea gravel.

d. The pea gravel shall be 3/8-inch in size and shall be free of foreign material, soil fines and roots.

e. A minimum of 6 inches of pea gravel shall be placed all around the pipe.

f. A 30-mil HDPE scuff pad shall be placed between the 80-mil FML and the underlying gravel as shown on the drawings.

2. Responsibilities

a. The CQA Officer shall inspect all collection pipe and labeling prior to use to verify that it is made of the specified materials, that pipe dimensions and perforations are as specified, and that pipe is relatively clean internally.

b. The CQA Officer shall inspect all scuff pads to verify correct locations.

c. The CQA Officer shall supervise the fusion-butt welding of the HDPE pipe and shall visually observe the pipe welding process to verify the proper joining of pipe.

d. The CQA Officer shall verify the collector pipe location invert levels and configuration.

e. The CQA Officer shall observe the placement of fabric wrap and pea gravel around the collection pipes, and document such observations.

f. The CQA Officer shall observe the placement of the pea gravel around the collection sump to verify correct placement and character of the pea gravel as shown on the drawings.

g. The CQA Officer shall certify that pipes were placed in accordance with cell engineering design plans.

C. Sump Collection

1. General Specifications

a. Sumps will be constructed as shown on the engineering design drawings.

2. Responsibilities

a. The EWC will construct sumps at the locations shown on the drawings.

b. The CQA Officer will observe and document the construction of the pressure relief system and collection sump. The details and dimensions shown on the engineering plans shall be verified and documented by the CQA Officer or his representatives. Any deviation from engineering plans shall be reported immediately to the CQA Officer.

c. The LSC shall determine elevations for the pipe inverts at the sump and for the bottom of the sump.

d. The CQA Officer shall certify that the pressure relief system collection sump has been installed in accordance with cell engineering design plans.

VIII. SECONDARY FML

A 80-mil HDPE liner will be placed upon the prepared subbase as shown on the drawings. Specifications for the placement of this secondary FML will be identical to those for the primary FML and contained in Section XIII of this document.

IX. LEAK DETECTION SYSTEM

A. General Specifications

1. On sideslopes, one layer of PN 4000 HDPE drainage net or approved alternate will be installed as shown on the drawings.

2. On the cell base, two layers of PN 3000 HDPE drainage net or approved alternative will be installed as shown on the drawings.

3. Beneath leachate collection mains or laterals, 5 layers of drainage net will be installed, as shown on cell engineering design plans.

4. All drainage net will be covered with a continuous layer of 8-ounce non-woven polypropylene fabric.

5. All net and fabric shall extend upward into the anchor trench and be restrained there with compacted soil.

6. All drainage net will be joined at an interval of 5 lineal feet or less. Drainage net fasteners will be used to connect individual net panels.

7. Minimum overlap of the polypropylene fabric shall be 4 inches and no loose flaps will be permitted on the upper surface. If fabric is dry, individual panels will be joined with a heat gun. If wet, the panels will be sewn together.

8. Drainage net and fabric will be stored in areas away from heavy traffic.

B. Responsibilities

The supervision of installation of drainage nets and fabrics may be performed wholly or in part by a contractor selected to perform this type of work. If no NFI installation contractor is selected, responsibilities assign to the NFI will be transferred to the CQA Officer.

1. The CQA Officer is responsible for keeping net and fabric stored in an area away from heavy traffic.

2. The NFI shall inspect all drainage net and fabric rolls stored on-site to verify that the proper materials have been received for the work. The NFI shall also inspect the material received for any damage which may have been caused by mishandling during transportation, unloading or storage.

3. The NFI shall document the overlap of nets and fabrics and shall inspect and document the method of joining/seaming of adjacent sheets.

4. The NFI shall document the number of layers of the drainage net, the method of fastening different portion of the net and the locations of the secondary collectors as shown on engineering design plans.

5. The CQA Officer will inspect the polyethylene pipe used to access the secondary sump to ensure that it is made of specified materials, that pipe dimensions and perforations are as specified and that the pipe is relatively clean internally.

6. The CQA Officer shall inspect the construction of the secondary monitoring sump access pipe to verify conformance with the engineering plans.

7. Upon completion of the leak detection system, the CQA Officer and the NFI together shall visually inspect all surfaces of the cell to verify total coverage and adequate fastening of individual sections and proper restraint of the covered area. The NFI shall submit written documentation to the CQA Officer that drainage net and fabric has been installed according to engineering design plans and that in-place materials generally meet

accepted standards for placement of net and fabric. The CQA Officer is responsible for final certification of the leak detection system.

X. PRIMARY 5-FOOT CLAY LINER CONSTRUCTION

Construction of the 5-foot compacted clay liner will occur following base preparation and installation of the secondary FML and leak detection systems. This plan is based on requirements detailed in Michigan Act 64 Rule 299.9621 (1)(c) and 299.9620(2), and on engineering analyses performed by NTH.

A. General Specifications

1. Clay soils used in the primary liner will have a USC of CL as determined by the provisions of ASTM Standard D2487.

2. To avoid damage to the underlying secondary liner and leak detection system, the first lift will be approximately 18 inches in loose thickness and will be compacted with a low ground pressure equipment. Equipment ground contact pressure will not exceed 41.5 psi.

3. The remaining layers of CL material used in the

compacted clay layer will be placed in horizontal lifts that will not exceed 9 inches (25 centimeters) in loose thickness.

4. The clay soil will be compacted to not less than 90% of maximum dry density as determined by the modified proctor compaction test, ASTM Standard D1557. Moisture content test, ASTM Standard D1557. Moisture content shall be within a range of -2% to +5% of optimum moisture as determined by the modified proctor compaction test, ASTM Standard D1557. More restrictive limits may be applied if needed to achieve shear strength and permeability criteria for the silty clay.

5. Moisture/density restrictions that apply to the native on-site clay and I-696 clay intended for use in the 5-foot compacted clay liner are presented on Plate 1, Cell II Liner System Construction Requirements.

6. The compacted clay layer will have a maximum permeability coefficient of 1×10^{-7} cm/sec.

7. Shear strengths of the compacted clay layer will not be less than 500 psf along the cell base

within the stabilization berms and along the inner face of the stabilization berms. In all other areas, the compacted clay shall have a shear strength of at least 2500 psf. (See Plate 1)

8. The 5-foot compacted clay liner will be constructed such that the bottom liner and the sidewall liner are continuous and completely keyed together at all construction joints. Where necessary, the EWC, under direction of the CQA, shall moisture condition the surfaces to receive clay fill either by addition of water and scarification where desiccated, or by discing to reduce water content of the clay liner.

9. During winter construction, all ice, snow and other frozen material will be removed before placing any clay. No fill will be placed on frozen surface and no frozen fill will be used in construction.

10. Foreign objects will be removed from the fill prior to placement.

B. Testing

1. The field density and moisture content of the compacted clay will be determined by the nuclear densimeter method (ASTM D2922 and D3017) on a frequency of at least 1 test per each 1000 cubic yards of clay placed, with a minimum of 1 test per day of construction or 1 test per layer of clay placed. When using the nuclear densimeter technique for field testing the compacted clay, care must be taken to avoid puncture of the underlying geomembranes.

2. The moisture-density relationship of liner materials will be re-determined according to ASTM Standard D1557 when the texture of the soil changes and every 5000 cubic yards placed. The grain size distribution, Atterberg limits and soil classification will also be determined at this frequency (ASTM D2487, D422, D4318). If a resultant classification is not CL, or if at least 25% of the soil particles are not less than 5 microns in size, the ITE will notify the CQA Officer of the situation.

3. A laboratory determination of the coefficient of permeability with water of a soil sample obtained from every 10,000 cubic yards of material placed will be made. Samples will be obtained by cutting blocks of soil or by Shelby tube sampling. The number of Shelby tubes shall not exceed 1/2 the total number of samples obtained for permeability testing. During sampling, care must be taken to avoid puncture of the underlying geomembrane. Falling head permeability tests will be performed according to one of the methods detailed in USEPA publication SW-925 (1984). A resultant coefficient of permeability greater than 1×10^{-7} cm/sec will be immediately reported to the CQA Officer.

4. Shear strength will be determined at a frequency of one test per day for materials placed with moisture contents within the ranges shown on Plate 1. If moisture contents are outside the specified ranges, or if soil characteristics change noticeably, shear strength tests will be performed at a minimum of one test per 2000 yards of material placed. Shear strength will be determined by field vane shear methods or by laboratory strength tests performed on Shelby tube samples obtained in

the field. The frequency of shear strength testing may be increased at the discretion of the CQA Officer.

C. Responsibilities

1. The CQA Office will direct all earthwork operations during primary clay liner construction.

2. The LSC will perform surveying as specified herein and as directed by the CQA Officer.

3. The CQA Officer will coordinate the surveying of the completed clay liner to verify proper lines and grades, in accordance with the engineering design plans. The thickness of the compacted clay liner shall not be less than 5 feet as measured normal to the underlying synthetic layers. The clay liner surface elevations on the cell bottom shall be checked on a 100-foot grid and shall be accurate to within 0.2 feet.

The elevations of the top and toe of sideslopes shall be surveyed every 100 feet along the top and toe of the slope. This data shall be used with

survey data collected before liner placement to determine clay liner thickness on the slopes.

Locations determined to have less than 5 feet of compacted clay shall be reported immediately to the CQA Officer for corrective action.

4. The CQA Officer will be responsible for overall construction quality assurance of the primary clay liner and will certify that the construction is performed according to design drawings and this CQA document.

5. The ITE or his representative will sample soils and perform laboratory testing at the frequency required herein.

6. The ITE or his representative will provide field density, moisture and strength testing of fill placed and will promptly notify the CQA Officer of materials or construction methods not in accordance with specifications.

7. The ITE or his representative will provide documentation to the CQA Officer in the form of a daily field report including date of work, weather

conditions, lift thickness, equipment used in construction, moisture and density test results, and any field strength test results.

XI. PRIMARY FML

An 80-mil HDPE liner will be placed upon the 5-foot compacted clay liner section as shown on the engineering drawings. Specifications for placement of this primary FML are contained in Section XIII of this document.

XII. LEACHATE COLLECTION SYSTEM

The proposed leachate collection and removal system will consist of a combination of granular drainage medium, synthetic filter-drainage geotextiles and a series of cell bottom pipes that empty into four leachate collection sumps. The leachate collection and removal system will be constructed in accordance with cell engineering design plans.

A. Granular System

1. General Specifications

a. The granular drainage blanket will consist of a 1-foot thick layer of MDOT Class II sand

placed over the base of the cell. The blanket will be free of foreign materials.

b. The permeability of Class II sand used in the leachate collection system will not be less than 1×10^{-2} cm/sec.

c. Placement of the granular blanket will be performed with construction equipment having a ground contact pressure less than 41.5 psi. No rubber-tired equipment will operate on top of the granular blanket in areas where the thickness of the blanket is less than 2 feet.

2. Testing

a. Material testing on the granular blanket will be performed in advance of receipt to determine its grain size distribution by sieve analysis (ASTM D422), and permeability (ASTM D2434). On this basis, the borrow source of the sand will be selected.

b. The permeability and aggregate classification of the sand will be determined for every 5000

cubic yards of sand placed to verify that the material is consistent with specifications contained within this document. A permeability of less than 1×10^{-2} cm/sec shall immediately be reported by the ITE to the CQA Officer.

c. The depth of the sand will be determined on a 100-foot grid by a survey or by direct depth checks.

3. Responsibilities

a. The ITE's representative will perform laboratory testing on sand at the frequency specified in this document.

b. The CQA Officer will direct the spreading of leachate collection sand and document sand material uniformity and the presence or absence of foreign materials. The CQA Officer shall also observe this operation to detect potential and actual damage to the 80-mil FML. Where damage is suspected, the liner surface shall be exposed to verify its condition. Actual damage shall be fully

documented and corrective action shall be taken in accordance with procedures outlined in Section XIII.

c. The CQA Officer will coordinate surveying on a 100-foot grid to verify leachate collection sand thickness. Alternately, direct depth checks may be used to determine sand thickness. Locations at which sand thickness is less than 12 inches shall be brought to the attention of the CQA Officer and remediated under his direction.

d. The CQA Officer will certify that the granular blanket has been placed in accordance with the engineering design plans.

B. Pipes

1. General Specifications

a. Six-inch diameter high density polyethylene (HDPE) pipe will be used in the leachate collection system. Pipes will have a standard dimension ratio (SDR) of 7.3 and 1/4-inch diameter perforations. Each lineal

foot of pipe will have 2 rows of perforations with individual perforation spaced at 4-inch intervals, i.e., 6 holes per lineal foot. Holes will be placed 90° apart.

b. MDOT Series 34 open-graded aggregate (pea gravel) will envelope leachate collection pipes as shown on cell engineering design plans. A non-woven polypropylene filter fabric (Amoco Propex 4545 or approved alternate) shall fully envelope the pipe and gravel section and function as an interface filter between the Class II sand and pea gravel.

c. A minimum of 6-inches of pea gravel shall be present in every direction surrounding the pipe. Pea gravel shall be 3/8-inch in size and contain no crushed stone.

d. Pea gravel shall be free of foreign material, soil fines and roots.

2. Responsibilities

a. The CQA Officer shall inspect all leachate collection pipe and labelling prior to use to verify that it is made of the specified materials, that pipe dimensions and perforations are as specified, and that pipe is relatively clean internally.

b. The CQA Officer shall inspect all 30-mil HDPE scuff pads placed at leachate collector pipe and temporary berm locations to verify their presence and correct location. The location of scuff pads shall be marked on the sideslopes both before and after placement of synthetic materials.

c. The CQA Officer shall observe the excavation of the sand layer for placement of the collector pipe system, to quickly detect and document any damage caused to the 80-mil FML by this operation. Corrective action shall be performed in accordance with Section XIII-F of this document.

d. The CQA Officer shall supervise the fusion-butt welding of the HDPE collector pipe and shall visually observe the pipe welding process to verify the proper joining of pipe.

e. The CQA Officer shall verify the collector pipe location and configuration and proper placement of leachate collector pipe cleanouts.

f. The CQA Officer shall observe the placement of fabric wrap and peastone around leachate collector pipes, and document such observations.

g. The CQA Officer shall observe the placement of the pea gravel around the leachate collection sump to verify correct placement and character of the pea gravel as shown on the drawings.

h. The CQA Officer shall certify that pipes were placed in accordance with cell engineering design plans.

C. Drainage Nets and Fabrics

1. General Specifications

a. One layer of PN 4000 HDPE drainage net or approved alternate will be placed along cell sideslopes. Polypropylene filter fabric will be laid over the 1-foot thick Class II sand layer and between the Class II sand and pea gravel enveloping collector pipes. The minimum permeability of this filter fabric shall be 0.1 cm/sec.

b. All net and fabric shall extend upward into the anchor trench and be restrained there with compacted soil.

c. All drainage net will be joined with fasteners at an interval of 2 lineal feet or less.

d. Minimum overlap of the polypropylene fabric shall be 4-inches and no loose flaps will be permitted on the upper surface. If fabric is dry, individual panels will be joined with a

heat gun. If wet, panels will be sewn together.

2. Responsibilities

a. The NFI shall install drainage net and fabrics at the locations shown on the drawings.

b. The NFI shall inspect all drainage net and fabric rolls stored on-site to verify that the proper materials have been received for the work. The NFI shall also inspect for any damage which may have been caused by mishandling during transportation, unloading or storage.

c. The NFI shall document the overlap of nets and fabrics and shall inspect and document the method of joining/seaming of adjacent sheets.

d. The NFI shall document the number of layers of net and the method of fastening.

e. Upon completion of the leak detection system, the CQA Officer and the NFI together shall verify total coverage and adequate fastening and restraint.

f. The NFI shall submit written documentation to the CQA Officer that drainage net and fabric has been installed according to engineering design plans and that in-place materials meet generally accepted standards of placement.

g. The CQA Officer will certify that drainage nets and fabrics used in the leachate collection system have been installed according to cell engineering design plans.

D. Sump Collection

1. General Specifications

a. Sumps will be constructed as shown on the engineering design drawings.

2. Responsibilities

a. The EWC will construct sumps at the locations shown on the drawings.

b. The CQA Officer will observe and document the construction of the primary leachate collection sump. Items requiring documentation include but are not limited to the following: placement of HDPE liners under the sump and welding them to the primary liner, placement of the precast concrete base for the leachate sump, placement of the polyethylene leachate sump, inspection of the concrete poured around the sump and proper fastening of leachate collector pipes and HDPE liners to the leachate sump. HDPE materials will be connected using an extrusion welding process in which a heat gun heats the HDPE surface and extrudes liquid HDPE to bond individual HDPE pieces. In all of the above operations, each detail and dimension shown in the engineering plans shall be verified and documented by the CQA Officer or his representative. Deviations of as-built

conditions from engineering plans shall be reported immediately to the CQA Officer.

c. The LSC shall determine elevations for the pipe inverts at the sump and for the bottom of the sump.

d. The CQA Officer shall inspect the polyethylene leachate sump and shipping certificates to verify that it is made of proper material type and is of specified dimensions. The inspections shall verify pipe type, dimensions and perforations in accordance with engineering plans, and that it is relatively clean.

e. The CQA Officer shall certify that the leachate collection sump has been installed in accordance with cell engineering design plans.

XIII. FML QUALITY CONTROL AND ASSURANCE

The FML Installer (FMLI) shall install both the 80-mil thick high density HDPE secondary liner and the 80-mil thick HDPE primary liner. Both the primary and secondary liners shall be

restrained at their upper edges at an anchor trench, with all trenches to be dug with a backhoe by the EWC. Seaming shall be accomplished using an extrusion-fusion type weld with a minimum sheet overlap of 4 inches at all seams. Extrusion-fusion type welding involves the use of a heat gun to heat the surface of the HDPE and extrude liquid HDPE that bonds individual panes.

The FMLI will also conduct its own quality control program which consists primarily of three parts: material testing at the point of manufacture, in-place seam integrity testing and destructive testing of seams. The CQA Officer shall appoint an independent testing engineer (ITE) to inspect the installation of the FML and to ensure that the FML quality control and quality assurance program outlined in this document is adhered to. Inspection performed by the ITE will supplement the FMLI's quality control program. The ITE will provide the CQA with information needed for the CQA to certify that it has been placed in accordance with cell engineering design plans.

A. FML Quality

1. Raw Material

a. The FML must be manufactured of first quality newly produced materials. The use of reclaimed polymers and other materials is not

permitted. Recycling of materials containing reinforcing scrim is not permitted. Recycling of materials that do not contain scrim is permitted.

b. The following documentation relating the FML raw material quality must be provided by the FMLI.

i. A statement identifying the origin of raw materials.

ii. A copy of the quality control certificates issued by the producer of raw materials.

iii. Reports on tests conducted to verify the quality of the raw materials.

2. Manufactured Rolls and Blankets

a. FML blankets or rolls must be designed and manufactured specifically for the purpose of fluid containment.

b. The FML must be free of holes, blisters, undispersed raw materials, and any sign of contamination of foreign matter.

c. The FML used as the secondary liner must be a minimum of 80-mils thick.

d. The FML used as the primary liner must be a minimum of 80-mils thick.

e. The 80-mil FMLs will have the material properties listed in Standard 54 of the National Sanitation Foundation (NSF) for HDPE material.

f. The following documentation relating to quality of manufactured FML rolls and blankets will be provided by the FML manufacturer:

i. Material Property Sheets - These sheets will pertain to the FML to be used for the project and will contain results of tests to verify compliance with the minimum acceptable standard properties specified by Standard 54 of the NSF.

The sheet must also provide any minimum properties guaranteed by the FML manufacturer and indicate the test method used.

ii. Quality Control Certifications- Certificates will pertain to rolls or blankets of material delivered to the site and will be signed by a responsible party employed by the FML manufacturer such as production manager.

iii. Each roll or blanket will be identified by a unique manufacturing number.

3. Factory Seaming

If factory seaming is performed, the FMLI will provide documentation of seaming conditions and the test results of factory seams.

B. Packaging, Storage and Handling of FML Prior to Installation

1. FML rolls or blankets must be packed and labeled prior to shipment to the site. The label must

indicate the FML manufacturer, type of FML, thickness, and roll or blanket number.

2. When transported to the site, FML rolls or blankets must be handled by appropriate means so that no damage is caused. Wooden cases must be strong enough to withstand impacts and rough handling without breaking or splintering.

3. The FML must be protected from direct sunlight and heat to prevent degradation of the FML material and adhesion between individual whorls of a roll or layers of a blanket. Adequate measure must be taken to keep FML materials away from possible deteriorating sources.

4. On site, the FML will be stored in an area away from heavy traffic.

5. Appropriate handling equipment must be used when moving the rolled or folded FML from one place to another.

C. Preparation of Subgrade

1. The subgrade for the secondary FML will consist of compacted clay fill, where necessary, along the base and sideslopes of Cell II shaped according to the subgrade plans.

2. The subgrade for the primary FML will consist of the 5-foot compacted clay primary liner overlying the secondary FML and the leak detection system.

3. Subgrades below the FML will be graded to eliminate protruding stones and deleterious materials. Deviation in design grade elevations of more than 0.2 feet are unacceptable.

4. The upper three inches of the layer must not contain protruding stones larger than 2 inches in diameter. Large stones will be removed by hand at the time of fill placement and preparation of cut slopes where applicable.

5. A smooth steel drum, pneumatic roller or other approved piece of equipment will be used to free subgrade surfaces of irregularities, loose earth and abrupt changes in grade.

6. No FML may be placed in ponded precipitation or in any area which has become softened by precipitation.

7. The CQA Officer will make provisions for material, personnel and equipment needed to prepare and maintain an acceptable subgrade surface.

D. Installation of FML

1. General Installation

a. FML rolls or blankets may be cut into panels, a unit area of membrane which is to be seamed. Individual panels will be designated a panel number. Instruction on the boxes or wrapping containing the FML materials must be followed to assure the panels are unrolled or unfolded in the proper direction for seaming. Care must be exercised to not damage the FML during this operation. All workers must wear shoes which will not damage the FML.

b. FML panels will be placed according to FML layout drawings prepared by the FMLI prior to

placement. The drawings must indicate the panel configuration and locations of seams. Field seams should be differentiated from factory seams (if any). In general, seams should be oriented parallel to line of maximum slope. In corners and odd shaped geometric locations, the total length of field seams should be minimized. No horizontal seams should be placed at the toe and should be a minimum of 1.5 m (5 feet) away from the toe of the slopes.

c. Pulling FML panels will be minimized to reduce permanent tension.

d. The following precautions will be taken to minimize the risk of damage by wind during panel placement.

i. No more than one panel should be unrolled prior to seaming (unless otherwise authorized by the installer).

ii. FML panels will be secured to prevent uplift by the wind during placement. Sand bags, tires or any other means

which will not damage the FML will be used to secure it. Along the edges, loading must be continuous to avoid possible wind flow under the panels.

e. Any panel which becomes seriously damaged (torn or twisted permanently) must be replaced. Less serious damage must be repaired according to Section XII$\frac{I}{A}$-F.

f. FML placement must not proceed at an ambient temperature below 1°C (34°F) or above 35°C (95°F) unless approved by the FMLI and CQA Officer.

g. FML placement must not occur during precipitation events.

2. Installation Around Appurtenances

a. The FML must be installed around the leachate collection manhole and an FML sleeve must initially be installed around the HDPE manhole riser. After the FML has been placed and seamed, the final field seam connection between the sleeve or shield and the FML

liner must be completed. A sufficient initial overlap of the sleeve must be maintained so that shifts in locations of the FML can be accommodated.

b. All clamps, clips, bolts, nuts or other fasteners used to secure the FML around each appurtenance must be made of stainless steel material.

E. Field Seaming and Testing

1. General Requirements

a. Panels shall be overlapped a minimum of 4 inches (100 mm).

b. Prior to seaming, the seam area must be cleaned of dust, dirt, debris of any kind, and foreign materials.

c. Seaming products shall be formulated in accordance with the FML manufacturer's specifications.

d. Seaming will be performed under favorable weather conditions.

e. Seaming on horizontal surfaces must commence at the center of a panel side and proceed to either side (if possible) in an effort to reduce wrinkle and subsequent fishmouths at the seam interface. Seaming shall extend to the outside edge of panels.

f. If the supporting soil is soft, a firm substrate must be provided by using a board or similar hard surface directly under the seam overlap to effect proper rolling pressure.

g. No loose flap of FML will be permitted on the upper surface of the completed installation.

h. Fishmouths or wrinkles at the seam overlaps must be cut along the ridge of the wrinkle back into the panel so as to effect a flap overlap. The cut fishmouths or wrinkles must be seamed and then patched with an oval or round patch of the same general FML extending a minimum of 6 inches (150 mm) beyond the cut

in all directions. The patch must be bonded over its entire perimeter.

2. Start-up Field Test Seams

a. Test seams must be performed to verify that seaming conditions are adequate. Test seams shall be conducted at least two times each day (at the beginning of the morning and the beginning of the afternoon) for each seaming method used that day. Test seams will be performed under the same conditions that panel seams are performed. Per ASTM D4437, the test seams must be at least 10 feet (3 m) long.

b. Specimens must be cut from the test seam. A 2-inch wide strip will be cut perpendicular to the seams. Specimens will be tested for shear strength by manually pulling each end of the strip. Test seams will be tested for peel strength by manually pulling the flap on the underside of the strip, away from the strip. If the test seam fails, an additional test seam shall immediately be conducted. If the additional test seam fails, the seaming

equipment or product must be rejected and not used for production seaming until the deficiencies are corrected and a successful test seam is produced.

c. A sample from each test seam must be retained and labeled with the date, ambient temperature, number of seaming unit, seamer, and pass or fail description. One half of the sample must be given to the FMLI and the other shall be retained by Ford.

3. Non-destructive Field Seam Testing

a. All field seams must be non-destructively tested over their length. Each seam must be numbered or otherwise designated. The installer shall document the results of the non-destructive testing.

b. Testing must be done as the seaming progresses, not at the completion of all field seaming. All defected found during testing must be numbered and marked immediately after detection. All defects found must be repaired, retested and remarked

to indicate completion of the repair acceptability.

c. All seams shall be fully tested by vacuum test methods, except as noted in Item 4 below.

d. All seams in special locations must be non-destructively tested if the seams are accessible to testing equipment. If any seam cannot be non-destructively tested, that seam must be observed by the CQA or his representative for uniformity and completeness and shall be so documented by the CQA.

4. Destructive Laboratory Seam Testing

Destructive seam testing shall be performed at a minimum of one destructive test per 350 feet of field seam length at locations to be determined by the CQA Officer. The samples shall be 16 inches wide by 24 inches long. One-half of the sample will be retained by the CQA Officer or his representative and one-half will be retained by the FMLI. The FMLI will perform five laboratory

tests for shear and peel strength on specimens cut from the seam sample. Four of the five replicate test results must pass the material specification requirements of the NSF Standard 54. Results of destructive testing shall be supplied to the CQA or his representative. In the event of destructive test failures, the FMLI shall determine the length of seam failure to the satisfaction of the CQA Officer or his representative. The area of failure must be reseamed or cap stripped. Test methods shall be: Shear Strength Test ASTM D816-Method B; Peel Strength Test ASTM D413-Method A or ASTM D816-Method C.

F. Repair of Defects

1. All seams and non-seam areas of the FML must be inspected for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter.

2. The surface of the FML shall be clean prior to use. Sweeping and/or washing of the FML surface is required if the amount of surface dust or mud inhibits inspection.

3. Repairs will be made in non-seam areas having defects, holes, blisters, undispersed raw material or any sign of contamination and on seams that have failed non-destructive testing.

4. Defective seams must be repaired by reseaming or applying a cap-strip. Tears or pinholes must be repaired by patching. Blisters, larger holes, undispersed raw materials, and contamination by foreign matter shall be repair by patches. Each patch must be numbered. patches must be round or oval in shape, made of the same generic FML and extend a maximum of 6 inches (150 mm) beyond the edge of defects.

5. Cap-strips must be at least 3 inches (75 mm) wide and must be centered over the completed seam edge. Cap-strips must be of the same generic FML material as the liner.

6. The thickness of cap-strip material used on the secondary FML must be at least 60 mils. The thickness of cap-strip materials used on the primary FML must be at least 80 mils.

7. Each repair must be non-destructively tested using the methods described in Section XIII-E. Tests which pass the non-destructive tests are taken as an indication of an adequate repair. Failed tests must be reseamed and retested until a passing test results. The results of all non-destructive testing performed on cap-strips must be documented.

G. Qualifications and Responsibilities of the FMLI

1. The FMLI must be trained and qualified to install 80-mile HDPE synthetic liners.

2. To demonstrate the necessary training and qualifications, the FMLI must provide to Ford the following information about at least three previous projects: name and purpose of the project; location; date; names of owner, designer and manufacturer; leader of the installer's crew; type of FML; thickness of FML; surface area; type of seaming; duration of installation; and available written information on the performance of the project.

3. FMLI personnel involved in field seaming operations must be qualified by experience or by successfully passing seaming tests.

4. At least one seamer must have experience seaming at least 100,000 square meters (1.07 million square feet) of an FML of the same generic type as the FML used for the project using the same type of seaming method. This master seamer must provide direct supervision over apprentice seamers.

5. Apprentice seamers must be qualified by attending training sessions taught by the master seamer and performing at least two successful seaming tests under similar weather conditions using the seaming method used for production seaming.

6. The FMLI must provide to Ford documentation indicating that the personnel involved in field seaming operations have experience and qualifications as outlined in Items 3 to 5 above.

7. The FMLI will be responsible for receipt, inspection and handling of FML materials as well as testing and repairing the FML when necessary.

8. The FMLI will provide to the CQA all documents relating to the quality of FML raw materials as well as manufactured rolls or blankets. The FMLI will provide the CQA with the following information:

   a. A statement identifying the origin of the raw materials.

   b. Quality control certificates issued by the producer of the raw materials.

   c. Reports on tests conducted to verify the quality of raw materials.

9. Upon arrival of the FML at the site, the FMLI will inspection all material for defects in manufacturing.

10. The FMLI must ensure that the following information is provided for rolls or blankets of FML material arriving on site:

    a. material property sheets
    b. quality control certificates

11. The FMLI must ensure that each FML roll or blanket arriving on site is labeled with the following information:

    a. FML manufacturer

    b. type of FML

    c. thickness of FML

    d. roll or blanket number

12. The FMLI must provide the CQA and the ITE a layout drawing of the proposed FML placement pattern and seams prior to FML placement.

13. The FMLI must inspect each FML panel for defects following placement and prior to seaming.

14. The FMLI must verify that the weather condition are acceptable for seaming. Ambient temperature and liner temperature will be recorded by the FMLI hourly during liner installation and field seaming.

15. The FMLI must provide suitable seaming equipment and products needed for seaming operations.

16. The FMLI will perform FML placement, seaming, test seaming, non-destructive testing and repairing according to procedures as outlined in Subsections D through F of this section.

17. The FMLI will record the following information for all non-destructive seam testing that is performed:

    a. location of non-destructive testing

    b. date

    c. test unit

    d. name of tester

    e. result of testing

18. The FMLI will record all information included under Item 17 above for non-destructive seam testing performed on all repairs.

19. The FMLI must retain a sample from each test seam and label it with the date, ambient air temperature, number of seaming unit, name of seamer, and result of test.

20. The FMLI must provide to Ford daily reports including the following information:

    a. total amount and location of FML placed

    b. total amount of seams completed and seaming units used

    c. changes in layout drawings

    d. results of test seams

    e. location and results of non-destructive testing

    f. locations and results of repairs

    g. location of and results of destructive seam testing, if performed

    h. acceptance of subgrade

H. Responsibilities of the ITE

1. The ITE or his representative will observe and document all field seaming operations including weather conditions, FML cleaning, overlaps, rate of seaming, names of seamers and seaming units used. He will also be on site to observe and document other phases of FML installation.

2. The ITE or his representative will also observe and document the phases of the FML installation that will include but not be limited to:

   a. Acceptability of subgrade preparation prior to the installation of the FML.

   b. Observations of test seams and non-destructive seam testing.

   c. Observations of repairs and testing including locations, name of repairer and seaming equipment of product used.

   d. Observations of seams around appurtenances and connections to appurtenance.

e. The above observations will be communicated to the CQA Officer through the submittal of a daily field report.

XIV. FINAL COVER QUALITY CONTROL ASSURANCE

Construction quality assurance responsibility will reside with Ford Motor Company. Construction of key elements of the cover system will be performed by the contractors retained by Ford Motor Company. Calculations and other references included in this section can be found in the closure plan prepared by Ford.

Construction monitoring activities and testing will be performed by an independent registered professional civil or geotechnical engineer (IRPE), or his representatives to verify that construction is in accordance with the construction requirements and design plans.

The IRPE will prepare a summary report detailing construction activities, observations, test data, construction problems encountered and corrective measures taken, deviations from design or material specifications and as-built drawings. The IRPE will provide a signed and dated statement of professional opinion to Ford Motor Company regarding construction of the cover system

according to the design plans and construction requirements. All such summary reports will be retained in the facility operating record by Ford Motor Company.

A. Construction of Bedding Layer

1. The layer upon which the FML is to be placed consists of a minimum of 12 inches of silt, clayey silt, or silty clay with an ASTM Method D2487-69 classification of ML, CL-ML, or CL.

2. The upper 4 inches of the layer must not contain particles larger than 1 inch in diameter.

3. The surface of the layer must be rolled with a smooth steel drum or pneumatic roller so as to be free of irregularities, loose earth, and abrupt changes in grade.

4. The FML installer (see XIV.C) must provide written certification as to the acceptability of the surface preparation of the layer prior to each days installation of FML.

5. Ford must make provisions for material, personnel, and equipment necessary to maintain an acceptable

surface of the bedding layer for FML installation.

6. Ford must obtain direct layer thickness measurements at a rate of at least once per every half-acre to verify conformance with design requirements.

B. Installation of Flexible Membrane Liner

The poly vinyl chloride (PVC) FML must be installed directly over the bedding layer described in Section XIV.A of this plan by an organization (installer) which is responsible for:

- Receipt, inspection and handling of FML materials and equipment

- The unrolling, placing, seaming, testing and repairing of the FML during installation

- And other aspects as assigned in this section.

C. FML Installer

The installer must be trained and qualified to install the type of FML to be used for the project. To demonstrate the necessary training and qualifications, the installer must provide Ford and the IRPE with experience documentation as required by 40 CFR 265.115. The installer shall provide evidence of having installed a minimum of 250,000 square meters. Required documentation includes the following information:

> Name and purpose of projects, location, date, name of owner, designer manufacturer, leader of the installer's crew, type of FML, thickness, surface area, type of seaming, duration of installation, and available written information on the performance of the project.

D. Basis of Design

At a minimum, the FML sheet must meet the specifications stated in the following excerpt adapted from the letter dated May 8, 1986 that was developed by NTH.

We have prepared an evaluation of the stresses on a 20-mil PVC liner during installation. In addition, we have calculated the percent elongation of the liner following settlement of the fill and consolidation of underlying clay. Finally, we compared these values with tensile and elongation standards published for PVC liners to determine whether or not the maximum allowable tensile stress and elongation might be exceeded during placement of the liner and/or following settlement of underlying materials.

Based on our calculations, we have concluded that the stress and strain on a 20-mil PVC liner during installation or following settlement should not exceed the allowable standard. During installation, the liner will be subjected to stresses from liner handling and placement. These stresses can be minimized by carefully following the manufacturer's placement instructions. However, placement of the liner on the sideslopes will probably cause a tension stress in the liner while it is supported only along the slope crest. Our calculations indicate that the tensile stresses acting on the 20-mil PVC liner during installation is approximately 0.12 pounds per inch width. This value is less than the minimum tensile strength standard of 46 lbs/in width for the 20-mil PVC. Standards for FML's are listed in the National Sanitation Foundation (NSF) Standard 54 for Flexible Membrane Liners (1985).

Following placement, the liner will experience elongation due to settlement. In our calculations, we conservatively assumed that the maximum settlement beneath the landfill cell would be imposed at the toe of the sideslopes (in reality, it would be expected to occur near the center of

the cell), and calculated the tensile strains that the liner would experience. Our calculations show that the elongation of the liner due to settlement is approximately 4%. Standard 54 lists the elongation at break for unsupported 20-mil PVC to be 300%. The allowable elongation in this liner is significantly greater than 4%. Based on these considerations, we do not expect damage to the liner to occur as a result of elongation following settlement.

E. Raw Materials

The FML must be manufactured of first quality newly produced materials. The use of reclaimed polymers and other materials is not permitted. Recycling of materials containing reinforcing scrim is not permitted. Recycling scrap that does not contain scrim is permitted.

The FML manufacturer must provide Ford and the IRPE with (1) a statement identifying the origin of raw materials; (2) a

copy of any quality control certificates issued by the producer of raw materials; and (3) reports on any tests conducted to verify the quality of the raw materials.

F. Rolls

1. The FML must be designed and manufactured specifically for the purpose of fluid containment. The FML must be free of holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.

2. The FML must be a minimum of 20 mils thick.

3. The following information shall be provided by the FML manufacturer as an indication of the quality of the material supplied:

   Material properties sheet pertaining to the FML to be used for the project, containing results of tests for tensile properties and tear resistance as specified by the NSF. The sheet must also provide any minimum properties guaranteed by the FML manufacturer and indicate test methods used.

Quality control certificates pertaining to the rolls of material delivered to the site must accompany the rolls. Each roll shall be identified by a unique manufacturing number. The quality control certificate shall be signed by a responsible party employed by the FML manufacturer, such as production manager, and shall be certified.

G. Factory Seaming

1. If the FML rolls are fabricated into designed blanket sizes before delivery to the site, one of the following seaming techniques must be used: adhesive, heat seaming, or dielectric seaming.

2. The overlap must provide the minimum required seam width. The seam must extend to the edge of the sheet, so that no loose flap is present on the top side of the fabricated blanket.

3. The rolls must be laid out without tension and seamed without wrinkles or fishmouths. If wrinkles occur within the sheet due to the seaming process, the wrinkle must not extend into the seamed width. Wrinkles which extend into the

seamed width must be treated as specified in Section XIV N.7.

4. The overlap area to be seamed must be free from moisture, dust, dirt, debris of any kind, and foreign material. The fabrication area must be in a clean, enclosed, temperature controlled facility.

5. Adhesive seaming shall be used with the PVC FML. Any adhesive used for seaming the rolls together must not be deleterious to the FML material in any way after seaming. The adhesive product must be applied as specified by the FML manufacturer with special attention to the ambient temperature and rolling pressure. The adhesive must be tested for longevity in contact with the FML material and its application must not result in appreciable stiffening of the FML. Prepared adhesive tapes must not be used.

6. The minimum seam widths shall be 25 mm (1 inch).

H. Packaging of FML

FML rolls or blankets must be packed and labeled prior to shipment to the site. The label must indicate the FML manufacturer, type of FML, thickness, and roll or blanket number.

I. Transportation of FML

When transported to the site, FML rolls or blankets must be handled by appropriate means so that no damage is caused. Wooden cases must be strong enough to withstand impact and rough handling without breaking or splintering.

J. On-Site Storage of FML

The FML must be protected from direct sunlight and heat to prevent degradation of the FML material and adhesion of individual whorls of a roll or layers of a blanket. Adequate measures must be taken to keep FML materials away from possible deteriorating sources (i.e., vandalism, theft).

K. On-Site Handling of FML

Appropriate handling equipment must be used when moving the rolled or folded FML from one place to another.

L. Panel Placement of FML

1. Each roll or blanket must be redesignated with a panel number. A panel is the unit area of in-place membrane which is to be seamed (i.e., one roll may be cut into several panels). Instruction of the boxes or wrapping containing the FML materials must be followed to assure the panels are unrolled or unfolded in the proper direction for seaming. Only the panels which are to be anchored or seamed together in one day shall be unrolled or unfolded. Care must be exercised to not damage the FML during this operation. All workers must wear shoes which will not damage the FML.

2. Pulling FML panels must be minimized to reduce permanent tension.

3. The following precautions must be taken to minimize the risk of damage by wind during panel

placement: no more than one panel should be unrolled prior to seaming (unless otherwise authorized by the installer); work shall be oriented according to the direction of the prevailing wind if possible; adequate loading on FML panels to prevent uplift by wind must be provided by sand bags, tires, or any other means which will not damage the FML. Along the edges, loading must be continuous, to avoid possible wind flow under the panels.

4. Any panels which become seriously damaged (torn or twisted permanently) must be replaced. Less serious damage must be repaired according to Section XIV.R.

5. FML placement must not be done during precipitation events.

M. Considerations of Site Geometry

1. Layout Drawings - The FML installer must provide Ford and the IRPE with layout drawings of the proposed FML placement pattern and seams prior to FML placement. The drawings must indicate the panel configuration and location of seams. Field

seams should be differentiated from factory seams (if any). In general, seams should be oriented parallel to line of the maximum slope. In corners and odd shaped geometric locations, the total length of field seams should be minimized. No seams should be placed at the toe, but should be a minimum of 1.5 m (5 ft) away from the toe of the slope.

2. Installation Around Appurtenances

a. The FML must be installed around the leachate collection manhole and an FML sleeve or shield must initially be installed around the concrete riser. After the FML has been placed and seamed, the final field seam connection between the appurtenance sleeve or shield and the FML must be completed. A sufficient initial overlap of the appurtenance sleeve must be maintained so that shifts in location of the FML can be accommodated. The installation of the leachate discharge pipe through the FML will be as shown on the Engineering Drawings.

b. All clamps, clips, bolts, nuts, or other fasteners used to secure the FML around each appurtenance must have a life-span equal to or exceeding the FML.

N. Field Seaming

1. Requirements of Personnel

a. All personnel performing seaming operations must be qualified by experience or by successfully passing seaming tests.

b. At least one seamer must have experience seaming at least one hundred thousand square meters (1.07 million sq ft) of a FML of the same generic type as the FML used for the project using the same type of seaming method. This master must provide direct supervision over apprentice seamers.

c. Apprentice seamers must be qualified by attending training sessions taught by the master seamer and performing at least two

successful seaming tests under similar weather conditions using the seaming method used for production seaming.

2. Overlapping

The panels shall be overlapped a minimum of 100 mm (4 inches).

3. Preparation

Prior to seaming, the seam area must be clean and free of moisture, dust, dirt, debris of any kind, and foreign material.

4. Seaming Equipment and Products

Any adhesive (bodied solvent compound or cement) used shall be formulated in accordance with the FML manufacturer's specifications.

5. Weather Conditions for Seaming

Weather conditions required for seaming are as follows: no welding shall be done below 1°C (34°F); between 1°C (34°F) and 10°C (50°F),

seaming is possible if the FML is preheated by either sun or hot air device, and if there is not excessive cooling resulting from wind; and above 10°C (50°F), no preheating is required. In all cases the FML must be dry.

6. General Procedure for Seaming

a. Seaming on horizontal surfaces must commence at the center of a panel side and proceed to either side (if possible) in an effort to reduce wrinkles and subsequent fishmouths at the seam interface. The direction of seaming on slopes shall be the most expedient direction for the type of seaming used. Seaming shall extend to the outside edge of panels.

b. If the supporting soil is soft, a firm substrate must be provided by using a homogeneous board or similar hard surface directly under the seam overlap to effect proper rolling pressure.

c. The width of the seam must be 100 mm (4 inches) starting from the edge of the FML placed on top (so there is no loose flap). Any loose flap must be bonded using an adhesive.

7. Procedure for Seaming Wrinkles

a. Fishmouths or wrinkles at the seam overlaps must be cut along the ridge of the wrinkle back into the panel so as to effect a flap overlap. The cut fishmouths or wrinkles must be seamed as well as possible, and then patched with an oval or round patch of the same generic FML extending a minimum of 150 mm (6 inches) beyond the cut in all directions.

b. The patch must be bonded over its entire area, using either a hot air gun or an adhesive (Bodied solvent or cement).

8. Cap-Strips

a. Cap-strips must be placed on all defective seams which are not repairable by reseaming,

in accordance with Section XIV.R.3. They must be placed only after quality control of the original seam has been performed.

b. Cap-strips must be at least 75 mm (3 inches) wide and must be centered over the completed seam edge. Cap-strips must be of the same generic FML material as the liner but without reinforcing scrim. The thickness of the cap-strip must be at least 20 mils.

O. Quality Control and Inspection

1. The test reports, material properties sheets, and quality control certificates required in Sections XIV.E and XIV.F must be supplied to Ford and the IRPE by the FML manufacturer prior to fabrication (or installation if there is no fabrication).

2. The quality control certificates must be reviewed by the FMLI to verify that a certificate has been received for all rolls.

P. Transportation, Handling, and Placement

1. Upon arrival of the FML at the site, the FMLI must inspect all materials for defects in the manufacturing process and for damage during transportation. Materials judged to be severely damaged must be rejected and removed from the site. Minor damages and other defects shall be repaired.

2. The FMLI must inspect each panel after placement and prior to seaming, for damage caused by placement operations or by wind. Damaged panels or portions of damaged panels which have been rejected must be marked and their removal from the work are recorded.

3. The FMLI must also verify that the weather conditions (air temperature, non-excessive wind, and lack of precipitation) are acceptable for panel placement, in accordance with Section XIV.N.5.

Q. Field Seams

1. Field Seaming Operations

The FMLI must verify that:

a. The seaming personnel have the qualifications required in Section XIV.N.1,

b. The overlaps meet the requirements presented in Section XIV.N.2,

c. The seaming area is clean, as described in Section XIV.N.3,

d. A hard substrate such as a board is used if the supporting soil is soft,

e. Seaming equipment and adhesive products are available on the site and meet the requirements presented in Section XIV.N.4,

f. Weather conditions for seaming are acceptable, as required in Section XIV.N.5,

g. Seaming procedures described in Section XIV.N.6 are followed,

h. The panels are properly positioned to minimize wrinkling and wrinkled areas are seamed according to the procedures presented in Section XIV.N.7,

i. All cap-strips required in Section XIV.N.8 are placed, and

j. Equipment for testing seams is available on site.

2. Test Seams

a. Test seams must be performed to verify the seaming conditions are adequate. Test seams shall be conducted at the FMLI's discretion and at least two times each day (at the beginning of the morning and the beginning of the afternoon), for each seaming equipment or adhesive product used that day. Also, each seamer must perform under the same conditions as production seaming. The test seam must be at least 0.6 m (2 ft) long.

b. Specimens must be cut from the test seam. These specimens must be 50 mm (2 inches) wide. Specimens shall be tested by hand in shear strength, and shall not fail in the joint. If the test seam fails, an additional test seam shall immediately be conducted. If the additional test seam fails, the seaming equipment or product must be rejected and not used for production seaming until the deficiencies are corrected and a successful test seam is produced.

c. A sample from each test seam must be retained and labeled with the date, ambient temperature, number of seaming unit, seamer, and pass or fail description. One-half of the sample must be given to the FMLI for subsequent laboratory testing and the other half retained by Ford.

3. Non-Destructive Seam Testing

a. All field seams must be non-destructively tested over their length. Each seam must be numbered or otherwise designated. The

location, date, test unit, name of tester, and outcome of all non-destructive testing must be recorded by the FMLI.

b. Testing must be done as the seaming progresses, not at the completion of all field seaming. All defects found during testing must be numbered and marked immediately after detection. All defects found must be repaired, retested and remarked to indicate completion of the repair acceptability.

c. The test unit shall be air lance or vacuum test unit.

4. Verification of Seam in Special Locations

a. All seams in special locations must be non-destructively tested if the seam is accessible to testing equipment. If the seam cannot be tested in-place, but is accessible to testing equipment prior to final installation, the seam must be non-destructively tested prior to final installation (i.e., seams around pipes and

gas wells). If the seam cannot be tested in-place or prior to final installation, it must be observed by the FMLI for final uniformity and completeness.

b. The seam number, date of observation, name of tester, and outcome of the test or observation must be recorded.

c. All defective seams must be promptly repaired, retested and remarked to indicate completion of the repair.

R. Repairs of Defects

1. Identification

a. All seams and non-seam areas of the FML must be inspected for identification of defects, holes, blisters, undispersed raw materials and any sign of contamination by foreign matter.

b. The surface of the FML shall be clean at the time of inspection. Sweeping and/or washing

of the FML surface is required if the amount of surface dust or mud inhibits inspection.

2. Evaluation

Each suspect location, both in seam and non-seam areas, must be non-destructively tested using the methods described in Section XIV.Q.3. Each location which fails the non-destructive testing must be marked and repaired.

3. Repair Procedures

Defective seams must be repaired by reseaming or applying a cap-strip. Tears or pinholes must be repaired by seaming or patching. Blisters, larger holes, undispersed raw materials, and contamination by foreign matter shall be repaired by patches. Each patch must be numbered. Patches must be round or oval in shape, made of the same generic FML and extend a maximum of 150 mm (6 inches) beyond the edge of defects.

4. Verification of Repairs

Each repair must be non-destructively tested using the methods described in Section XIV.Q.3. Tests which pass the non-destructive tests are taken as an indication of an adequate repair. Failed tests must be reseamed and retested until a passing test results. All non-destructive testing of repairs and the number of each patch, date, location, patcher and test outcome must be recorded.

S. Documentation

1. Material Quality Control Certificates

The quality control certificates pertaining to raw materials and manufactured FML rolls required in Sections XIV.E and XIV.F must be provided by the FML manufacturer to Ford prior to installation. The test results shall be reviewed for completeness and for compliance with the required minimum properties for both the raw materials and manufactured rolls. Materials and rolls which are in non-compliance with the minimum required properties must be rejected.

2. Daily Field Installation Reports

a. The FMLI must provide Ford with daily reports of: (1) the total amount and location of FML placed, (2) total amount and location of seams completed and seamer and units used; (3) changes in layout drawings; (4) results of test seams; (5) location and results of non-destructive testing; (6) location and results of repairs; and (7) location of destructive test samples.

b. Ford representatives must record daily all activities of the FML installation which shall include, but are not limited to: receipt of written daily acceptance of surface preparation from the FMLI; observations of field seaming operations, including weather conditions, cleaning, overlaps, rate of seaming, names of seamers and units used; observations of seams around appurtenances, and connection to appurtenances; observations of non-destructive seam testing, including testing location of defects and testing unit used; and observations of repairs and testing,

including locations, name of repairer and seaming equipment of product used.

c. Construction of the FML Protection/Drainage Blanket Layer

i. The granular material comprising this layer must be classified as MDOT Class II sand, based on at least one sampler per 5000 cubic yards.

ii. Drainage pipe must consist of 4-inch diameter corrugated polyethylene perforated pipe, placed as shown on the design plans. Perforations shall be 0.25 inches in diameter or width and will provide at least 0.25 square inches of open area per foot of pipe length.

iii. The pipe must be wrapped with geotextile filter material possessing an equivalent opening size of no greater than the opening size of a #70 standard sieve (Amoco Propex 4545).

iv. The granular material comprising the layer must be placed on the FML in a manner that does not damage it or the drainage pipe system.

v. Initial granular material placement must be done by placing the material at the toe of the lined slope and pushing the materials up the sideslope with track-mounted vehicles.

vi. The full design thickness of the granular material layer must be maintained when spreading the material and for construction traffic on the layer.

vii. Ford representatives must obtain direct layer thickness measurements at a rate of at least once per every half-acre to verify conformance with design requirements.

viii. Calculations for tensile stress during construction acting on the liner with one foot of granular blanket in place is

approximately 0.27 psi. The moduli at 100% elongation listed in Standard 54 (NSF) for 20-mil PVC is 8 lbs/in width. Since the stress acting on the liner with one foot of granular material in place is less then the stresses that would cause yield, and provided that the granular material is installed in the specified manner, puncturing of the liner should not occur during placement of the one-foot thick granular blanket.

d. Construction of Clay Layer

i. A compacted, cohesive soil layer must be placed over the FML protection drainage blanket layer described in Section XIV.S.2.c of this plan.

ii. The field density-moisture of the liner material shall be determined utilizing the provisions of ASTM Standard D2922-78 for each 1,000 cubic yards placed, with a minimum of 1 test per day of construction or layer of clay placed.

iii. The particle size distribution (sieve and hydrometer), Atterberg limits according to ASTM Standard D423-66 and ASTM Standard D424-59, and natural moisture content according to ASTM Standard D422-63 of random samples of clay liner material from each 5,000 cubic yards shall be determined. Samples must have more than 25% of the soil particles less than 5 microns in size and comply with the criteria for a Unified Soil Classification CL or CH as determined by the provisions of ASTM Standard D2487-69.

iv. The density of liner materials shall be determined by the modified proctor test, ASTM Standard D1557-70, when the texture of the soil changes and every 5,000 cubic yards placed.

v. The permeability with water of a soil samples shall be determined with water every 10,000 cubic yards placed by the constant head method, ASTM Standard 2434-68; triaxial cell method, as

described in the EPA document entitled "Soil Properties, Classification, and Hydraulic Conductivity Testing", which is adopted by reference in R299.11008; or other method approved by the director on a sample which is not less than 3 inches in diameter.

vi. Clay shall be placed in horizontal lifts of not more than 25 centimeters and be uniformly and thoroughly compacted to the standards approved in the design. However, the material shall not be compacted to less than 90% of the dry density, as determined by the modified proctor test described in the provisions of ASTM Standard D1557-70, adopted by reference in R299.11001, and the moisture content shall be within a range of -2% to +5% of the optimum moisture content.

vii. The compacted clay shall have a maximum permeability coefficient of 1.0×10^{-7} cm/sec or less at all points.

viii. No frozen soil may be used in any lift, nor may any soil be placed on frozen base.

ix. The soil must not be placed in a manner that would trap ponded water.

x. Material, personnel, and equipment such as discs, harrow or plow, and sprinkling system must be available.

e. Compacted Soils

i. Clean fill 1.5-foot lift thickness.

ii. Ford representatives must obtain direct measurements of soil thickness at the rate of at least once per every half acre.

f. Topsoil Specifications

i. A layer of topsoil at least 6 inches thick after grading must be placed over the clay described in Section XIV.S.2.d of this plan.

ii. The topsoil must be a sandy loam, loamy sand, or silt loam confirmed by grain size analyses conducted according to ASTM MEthod D422-63 at least once for every 3,000 cubic yards to be placed.

iii. The top 1/2-inch of the topsoil layer must be loosely packed to provide an acceptable seed bed.

iv. Ford representatives must obtain direct measurements of topsoil thickness at the rate of at least once per every half-acre to verify conformance with XIV.S.2.e.

g. Vegetative Cover Specifications

i. The topsoil described in XIV.S.2.e must be fertilized with 12-12-12 N-P-K at the rate of 650 lbs/acre.

ii. The following seed mix must be sown into the topsoil:

SEED	% BY WEIGHT
Common Cereal Rye	20 - 30
Common Creeping Red Fescue	20 - 30
Common Kentucky Bluegrass	5 - 10
Kentucky 31 Tall Fescue	100 - (sum of the above)

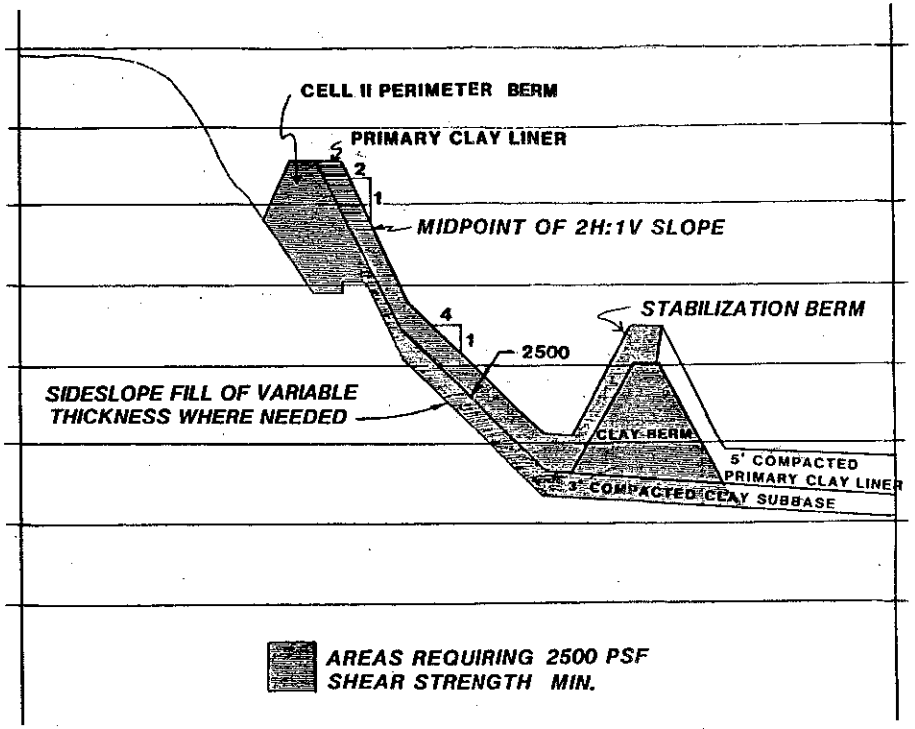
iii. The seed mix must have a germination rate of at least 80%.

iv. The seed mix must be applied at the rate of 200 to 225 lbs/acre.

v. The seed bed must be rolled during or immediately after seed application.

vi. Straw mulch must be applied to the seed bed at the even rate of 1.5 to 2 tons/acre in a manner that will minimize subsequent displacement by wind.

PERMEABILITY (K) & SHEAR STRENGTH (S) SPECIFICATIONS FOR CONSTRUCTION PHASES	MOISTURE / DENSITY REQUIREMENTS	
	NATIVE ONSITE CLAY	I-696 CLAY
1. Cell II Subbase Fill within Stabilization Berm K = 1 X 10^{-6} cm/s S = 500 psf	90% -2% → + 5%	90% -2% → + 5%
2. Cell II Stabilization Berms K = 1 X 10^{-6} cm/s S = 2500 psf	90% -2% → + 5%	90% -2% → + 3%
3. Cell II Sideslope Fill K = 1 X 10^{-6} cm/s S = 2500 psf	90% -2% → + 5%	90% -2% → + 3%
4. Cell II Perimeter Berms K = 1 X 10^{-6} cm/s S = 2500 psf	90% -2% → + 5%	90% -2% → + 3%
5. Five-Foot Compacted Clay Liner along Cell Sideslopes K = 1 X 10^{-7} cm/s S = 2500 psf	95% opt. → + 5%	90% -2% → + 3%
6. Five-Foot Compacted Clay Liner inside Stabilization Berms K = 1 X 10^{-7} cm/s S = 500 psf	95% opt. → + 5%	90% -2% → + 5%



CELL II LINER SYSTEM CONSTRUCTION REQUIREMENTS
ALLEN PARK CLAY MINE
FORD MOTOR COMPANY
DEARBORN, MICHIGAN

NEYER, TISEO & HINDO, LTD.
CONSULTING ENGINEERS AND GEOLOGISTS
38955 HILLS TECH DRIVE • FARMINGTON HILLS, MI 48018

PROJECT NO.: 86347ow	DRAWN BY: FK	DATE: 3-30-88
SCALE: - NO SCALE	CHECKED BY: CJM	SHEET OF

PLATE 1